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PCT/GB2005/000437

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The Patent Office

Cardiff Road
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1. Your reference: IT/LT/N15253

2. Patent application number *(The Patent Office will fill this part)*: 0402796.7 — 09 FEB 2004

3. Full name , address and postcode of the or of each applicant *(underline all surnames)*

Anson Medical Limited
67 Milton Park
Abingdon
Oxfordshire,OX14 4RX United Kingdom

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation: United Kingdom — 7917552001

4. Title of the invention

An Endoluminal Surgical Delivery System

5. Name of your agent *(if you have one)*: Williams Powell

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*:
Morley House, 26-30 Holborn Viaduct
London
EC1A 2BP

Patents ADP number *(if you know it)*: 5830310001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country *(if you know it)*	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application.

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(answer 'Yes if:*
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Description	13
Claim(*s*)	
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Priority documents	
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
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Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/we request the grant of a patent on the basis of this application.

Signature  Date 9 February 2004

12. Name and daytime telephone number of person to contact in the United Kingdom — Mr Lee Anderson 020 7936 3300

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An Endoluminal Surgical Delivery System

This disclosure relates to a delivery system for small surgical implants that are positioned intra-murally or trans-murally. The delivery system can be introduced endoluminally and the delivery system is likely to have other applications where a temporary or permanent implant needs to be delivered within a vessel but at a controlled and significant distance from the central axis of that vessel.

Examples of vascular devices that will benefit from the delivery system are fixation staples or clips, occlusion coils, anastamosis devices and stents, when they are at least partially passed through the walls of a previously implanted graft. The preferred embodiment of the delivery system will enable staples, clips or other fixation devices to be passed from within the lumen of a vessel, through the wall of a graft or stent-graft and at least partially through the wall of the vessel, thereby attaching the graft or stent-graft to the vessel wall.

Endoluminal surgery is a rapidly expanding field and permits implants to be delivered and minor surgical procedures to be carried out within the lumen of vessels, most commonly in arteries. The main instruments used in the technique to traverse the arterial tree, from a puncture site in the skin to the destination site of the procedure, are guide wires, which pass through the vessel, and catheters, which are passed over the guide wires. By appropriate choice of combinations of guide wire and catheter, the wires can be advanced through the vascular tree to the desired delivery site. Frequently, a stent or stent-graft (which are essentially open cylindrical structures) are passed through the catheter from outside the patient to the delivery site and, when released, these stents or stent-grafts expand to lie coaxially with the native vessel, their walls lying in close contact with the walls of the vessel.

Currently, it is very difficult to direct a guide wire or catheter into the wall of a vessel at a specific site because wires and catheters tend to lie approximately parallel to the axis of a vessel. Surgery will be eased by the ability to follow a guide wire along the axis of a vessel to a certain point and then to be able to move laterally away from the guide wire to deliver an implant in a position which is displaced from the wire, possibly in the wall of the vessel and not parallel to the principle axis of the vessel.

The system can be thought of as involving two guiding means, primary and secondary. The primary guiding means is generally a conventional guide wire and is introduced from outside the patient, through the patient's vessels to at least as far as the intended delivery site of the small implant. The secondary guiding means is able to follow the primary guiding means for at least part of the length of the primary guiding means. Said secondary guiding means is controlled by the practitioner so that at a point along the primary guiding means, the secondary guiding means can be wholly or partially separated from the primary guiding means and steered in a direction which is different from that of the primary guiding means.

Preferably, either one of the primary or the secondary guiding means is provided with a locking means which can be used to lock at least the secondary guiding means in place within the vessel to prevent both axial and lateral movement in that vessel. In the preferred embodiment, the locking means also prevents rotation of the secondary guiding means around the principal axis of the vessel.

The preferred embodiment of the secondary guiding means involves sets of components with two distinct functions. The first set of components controls the angle that the secondary guiding means makes with the wall of the vessel and preferably this is achieved by controlling the angle made by the secondary guiding means to the primary guiding means. Preferably, the angle which can be made between the secondary guiding means and the wall of the vessel can be controlled by the practitioner to be up to 90° and for the greatest range of uses, the angle made

between the secondary and primary guiding means should be capable of being larger than 90°, i.e. the tip of the secondary guiding means can be angled to point backwards with respect to the tip of the primary guiding means. Useful functions can be achieved with less sophisticated embodiments if the angle is at least 45°, although some anatomies and some functions will not be accommodated with this restricted angle.

It is preferable that the angle made by the secondary guiding means to the wall of the vessel can be controlled and varied by the practitioner, however simpler systems will operate with a fixed angle when the implant or surgical procedure can tolerate this limitation.

The second set of components of the secondary guiding means controls the distance of the tip of the secondary guiding means from the wall of the vessel and preferably this is achieved by controlling the distance of the tip of the secondary guiding means from the primary guiding means. For some applications, such as the delivery of staples, clips or pins through the wall of a graft or vessel, the tip of the secondary guiding means must be in contact with the vessel wall. In some cases, the tip must be able to apply significant pressure against the graft or vessel wall so that deployment of the staple, clip or pin does not push the wall away from the tip of the secondary guiding device. Thus the distance of the tip of the secondary guiding device from the vessel wall and the force which it applies to the vessel wall are to be controllable by the practitioner.

Such a system as described in general terms above is particularly difficult to design for larger vessels, such as the aorta, because the diameter of the vessel is such that a stiff guiding means is needed to traverse the width of the vessel and to provide support to deliver a trans-mural implant. However, stiffness of the guiding means must be sufficiently low to permit tracking through the vascular tree to the delivery

site and it is difficult to achieve an appropriate degree of stiffness to meet these opposing requirements.

A particular use of such a delivery system is to allow an appropriately designed fixator pin or staple to be introduced through vessels along a guide wire and then, when the delivery site is reached, to divert the fixator or staple away from the guide wire and drive it through a graft to attach it to the wall of a vessel. This is of particular benefit in attaching stent-grafts to the walls of vessels in order to prevent or stop migration of the stent-graft.

A simple method of constructing a delivery system with the properties described above is to combine at least one balloon, which is mounted on a catheter, with a separate sheath. The balloon's catheter and the sheath are attached to each other for at least part of their length and in one embodiment, these two components can be constructed from a single tubular component with two lumens. In this case, the two lumens are preferably linked by a thin, flexible plastic web which can be easily divided.

In an alternative embodiment of the invention, the balloon's catheter and the sheath are separate parts which are joined at a single point close to the tip of the sheath. The attachment means used to make the said join allows the axis of the end of the sheath to make a changeable angle with respect to the axis of the balloon's catheter, while preventing the sheath from sliding up and down with respect to the catheter.

Typically, the balloon's catheter is manufactured from an extruded plastic material with an internal diameter sufficient to permit standard guide wires to pass through. In aortic surgery, the diameter of guide wires most commonly used is 0.035" and occasionally 0.038" although in other surgical sites, wires as small as 0.014" are used. By designing the balloon's catheter to be able to run over a previously introduced guidewire, the balloon's catheter comprises the primary guiding means described

above. Preferably, the balloon's catheter is extruded with at least two lumens where the first lumen is used to pass over the guide wire and the second lumen transmits fluid used to inflate the balloon.

In some applications, it is preferable to include a metallic or similar stiff braid into the structure of the walls of the balloon's catheter in order to improve the transmission of torque from the practitioner, through the catheter, to the tip of the device. Typical external diameters of the balloon's catheter for use in the aorta will lie in the range 1.5mm to 3.0mm, although this size range will be scaled down for smaller vessels and smaller guide wires.

The construction of endovascular balloons is well known in the art. The balloon used in the preferred embodiment should be relatively compliant and operated at low pressures. Compliant balloons are typically manufactured from rubber, such as latex rubber or from elastic polymers such as polyurethane. Such balloons are typically inflated to pressures of approximately 2 atmospheres, although 5 atmospheres is used in some, less compliant balloons. High pressure balloons such as those manufactured from polyester or Mylar film are usually operated at pressures of several tens of atmospheres in order to dilate stenoses. Such balloons and pressures can be used in this device but are less effective unless the size of the balloon matches closely the size of the vessel in which it is placed.

Preferably, the balloon is designed so that it does not entirely occlude the vessel but provides some passage for blood to flow through or past it. This can be achieved by using more than one balloon, typically three balloons, located at the same axial point on the balloon's catheter and distributed around the catheter. When inflated the three balloons swell to form a 'clover leaf' shape which allows blood to flow through the spaces between the lobes and past the balloon.

Alternatively, single balloons can be constructed with fenestrations. In the simplest case, an annular balloon (resembling a doughnut) is inflated with the balloon's catheter filling the balloon by an attachment point on the surface of the inner ring of the doughnut. In this case, the catheter is slightly offset from the mid-line of the balloon. When inflated, the central fenestration of the balloon will provide a convenient channel for the through-flow of blood. If the balloon is designed not to be axi-symmetric, the balloon's catheter can be arranged to lie on the axis of the vessel but the balloons' fenestration must then be offset.

Alternative locking mechanisms to balloons can be constructed from strips of suitably springy material such as wire or strip metal which are arranged to 'balloon' out. Such an arrangement is constructed by distributing at least two approximately equal length wires or strips uniformly around a central shaft and attaching the ends of the strips to collars or similar structures which can slide over the shaft. When the collars are pushed or pulled together by appropriate means, the wires or strips will 'balloon' out from the shaft to lock across the width of the vessel. Other versions of the concept are also possible in which stiffer strips or wires are employed with hinges placed at points encountering large strains when the locking device is expanded, such as at the collars and in the mid part of the strips or wires. An attractive manufacturing technique for such a construct is to use injection moulding to form the strips from plastic, the hinges being constructed from sections of the same plastic where the thickness has been greatly reduced (so called 'living hinges').

Typically the sheath also comprises an extruded plastic tube. Preferably at least the inner surface of the sheath is treated to have a low sliding friction, either by means of a lubricant, such as a silicon-based grease or oil, or by extruding or coating at least the luminal part of the sheath from a hard or low friction plastic such as PTFE. In some applications, it is preferable to include a metallic or other similar braid into the structure of the walls of the sheath in order to improve the transmission of torque from the practitioner, through the sheath, to the tip of the device. In some embodiments of

the device, the properties of the sheath will preferably vary along the length of the sheath. At the tip of the sheath, the last few centimetres can benefit if made to be less flexible than the rest of the sheath and preferably a pre-set bend is formed in this stiffer region so as to direct the sheath away from the balloon's catheter. In this way, the sheath comprises the first part of the secondary guiding means.

Other variations can be devised for instance to allow the sheath to penetrate some distance down small, side-branch vessels. In this case, it may be advantageous for the last few centimetres of the tip of the sheath to be flexible so that it can track down the side branch. A stiffer, pre-curved section would then be position just behind this deformable tip so as to direct the tip away from the balloon's catheter.

In a further variation of the sheath, at least one stay or tensioning element manufactured from a filamentous material such as a braided or monofilament surgical suture or wire is attached close to the tip of the sheath and is preferably fed through at least one additional lumen for at least part of the length of the sheath. When tension is applied to at least one of the stays or tensioning elements in such a way that more tension is applied to one side of the sheath than another, then the sheath will bend in the direction of the greatest tension.

In the simplest embodiment of this variation, a single stay is connected close to the tip of the sheath and runs back from the tip for a distance of between 2cm and 10cm, at which distance it passes through a small hole in the wall of the sheath and continues to run back for the whole of the rest of the length of the sheath inside the sheath, preferably within its own lumen. Where the sheath exits the patient's body, the stay is attached to some independent gripping means. When the practitioner pulls on the independent gripping means and applies tension to the stay, while at the same time holding the sheath to prevent the stay from pulling it out of the patient, the tip of the sheath will bend in response to the tension in the stay.

In all arrangements here described, the first function of the first balloon or group of balloons is to fix the balloon's catheter in the vessel to prevent it from moving axially, laterally or from rotating.

A second function of the first balloon is to permit the sheath to form its curve away from the balloon's catheter using the full diameter of the vessel. This allows the radius of the bend of the tip of the sheath to be greater which permits it to be manufactured from stiffer material and which permits longer or stiffer implants or devices to be passed therethrough. Were the sheath to bend away directly from the balloon's catheter towards the wall of the vessel without first reaching the opposite wall of the vessel, the bend of the sheath would have to be completed within just the radius of the vessel requiring the tip of the sheath to be more flexible and restricting the stiffness or length of implants or devices past through the sheath.

A third function of the first balloon is to deflect the sheath so that it bends away from the balloon's catheter and is pushed against the wall of the vessel, locking it in place. In use, the position at which the sheath is pressed by the balloon against the vessel wall is approximately opposite the part of the wall where the tip of the secondary guidance means is intended to contact.

A fourth function of the first balloon is to support the sheath at approximately the midpoint of its traverse from one wall to the opposite wall of the vessel. Where this is a significant distance, such as in the aorta, the sheath can lack the stiffness required to deliver a staple or fixation device successfully. Attachment of the sheath at this said approximate midpoint approximately halves the unsupported length of the sheath and greatly increases the stability of this part of the delivery system.

Where two balloons or groups of balloons are employed, the function of the second balloons or group of balloons is both to provide supplementary fixation and also to occlude or reduce the flow of blood. This is because in some applications, such as

stapling at the neck of an aortic aneurysm, the first balloon may be situated within part of a stent-graft that is not well fixed to the walls of the vessel. In this case, inflation of a single balloon and the subsequent force of blood upon it may cause the balloon to dislodge the stent-graft, causing it to migrate before a fixation device has been deployed. In this type of case, the second balloon can be inflated upstream of the first balloon in a region of the vessel where there is no stent-graft or where the second balloon will be firmly fixed against the wall of the vessel. Once inflated, the second balloon will reduce or occlude the pressure of blood striking the first balloon, reducing or removing the risk of it migrating and causing an unwanted migration of a stent-graft or other such structure.

Preferably the first balloon or group of balloons can be inflated independently of the second balloon or group of balloons, for example by the use of separate inflation lumens in the balloon's catheter.

Typically the sheath will have an internal diameter between 1mm and 7mm depending upon the application.

Some benefits may accrue if more than one sheath is deployed around the balloon's catheter as this permits the simultaneous, or near-simultaneous deployment of more than one implant or device at different points around the circumference of the vessel. Such a modification to the design at its simplest involves the duplication of the sheath components.

In the simplest embodiment, a delivery catheter is passed through the sheath. At the tip of the sheath, which is arranged either by pre-curvature or by the action of the balloon or by both of these characteristics, to point away from the balloon's catheter, the delivery catheter can be advanced through the tip of the sheath and towards its eventual target site. Thus the delivery sheath can be pushed into contact with the wall of the vessel and can be made to exert a significant force against that wall. In some

embodiments, the tip of the delivery catheter is also curved in order that it makes a greater angle with the axis of the balloon catheter.

In some applications, the delivery catheter is conveniently pre-loaded with a staple or other fixator. Preferably, the sheath is fitted with a haemostatic valve at the end which lies outside the patient and this permits the delivery catheter to be completely withdrawn from the delivery system after its staple of fixator contents have been deployed. Once removed, the delivery catheter cane be replaced with a second delivery catheter, allowing a subsequent staple or fixator to be deployed without having to move the delivery system from the deployment site of the previous staple or fixator.

For the application of deploying staples disclosed in WO 01/58363 in the name of the present applicant in which the staples are biased to open outwards from an initial, approximately linear configuration, the diameter of the lumen of the delivery catheter will preferably lie in the range 2mm ± 1mm. These dimensions are appropriate for staples of the said design which have a deployed width lying in the range 10mm to 15mm. Other sizes of staple will require appropriate scaling of the diameter of the delivery catheter.

Preferably, an overall sheath is used to contain the balloon, balloon's catheter, the sheath and the delivery sheath. Preferably, the tip of the balloon's catheter is furnished with a tapered nose cone that will allow the overall sheath to pass through the vessels without damaging the vessel walls. The diameter of the overall sheath will lie in the range 8 to 30 French (2.6mm to 10mm) although currently constructed prototypes lie in the range 14 French to 20 French (4.6mm to 6.6mm). Slightly smaller systems can be designed with sheath sizes of 5French but these systems involve the finest guidewires, dual or multiple purpose lumens and advanced materials. Preferably the overall sheath is constructed from a stiff plastic such as

nylon or PTFE and itself is fitted with a haemostatic valve to prevent leakage of blood where the sheath and balloon's catheter exit from the back of the overall sheath.

Preferably, at least one of the sheath, the balloon's catheter and the delivery sheath are fitted with a suitable handle or gripping region to allow the practitioner to manipulate these tubes from outside the patient.

In use the following steps are used to deploy a staple such as that disclosed in WO 01/58363 (the contents of which are incorporated herein by reference):

- A guide wire is introduced into the patient so that it lies in the vessel into whose wall the staple is to be delivered. The guide wire is preferably advanced several tens of centimetres beyond the delivery site.

- The delivery site is identified, typically by means of fluouroscopy and radio-opaque dye.

- The delivery system is fed onto the guide wire with the wire passing through the lumen of the balloon's catheter.

- The delivery system is advanced through the patient until the end of the sheath is approximately opposite the intended delivery site of the staple.

- Holding the delivery system still, the overall sheath is pulled back to release the balloon and sheath within the vessel.

- The balloon and sheath are manipulated until the sheath is pointing at the correct part of the wall of the vessel.

- The balloon is inflated.

- The delivery catheter is advanced through the sheath until it is in near contact with the wall of the vessel.

- Pressure in the balloon is slightly reduced to permit fine adjustment of the position of the tip of the delivery catheter.

- When the tip of the delivery catheter is correctly aligned, the balloon is inflated up to its maximum recommended pressure.

- The delivery catheter is pushed firmly against the wall of the vessel and the staple is deployed.

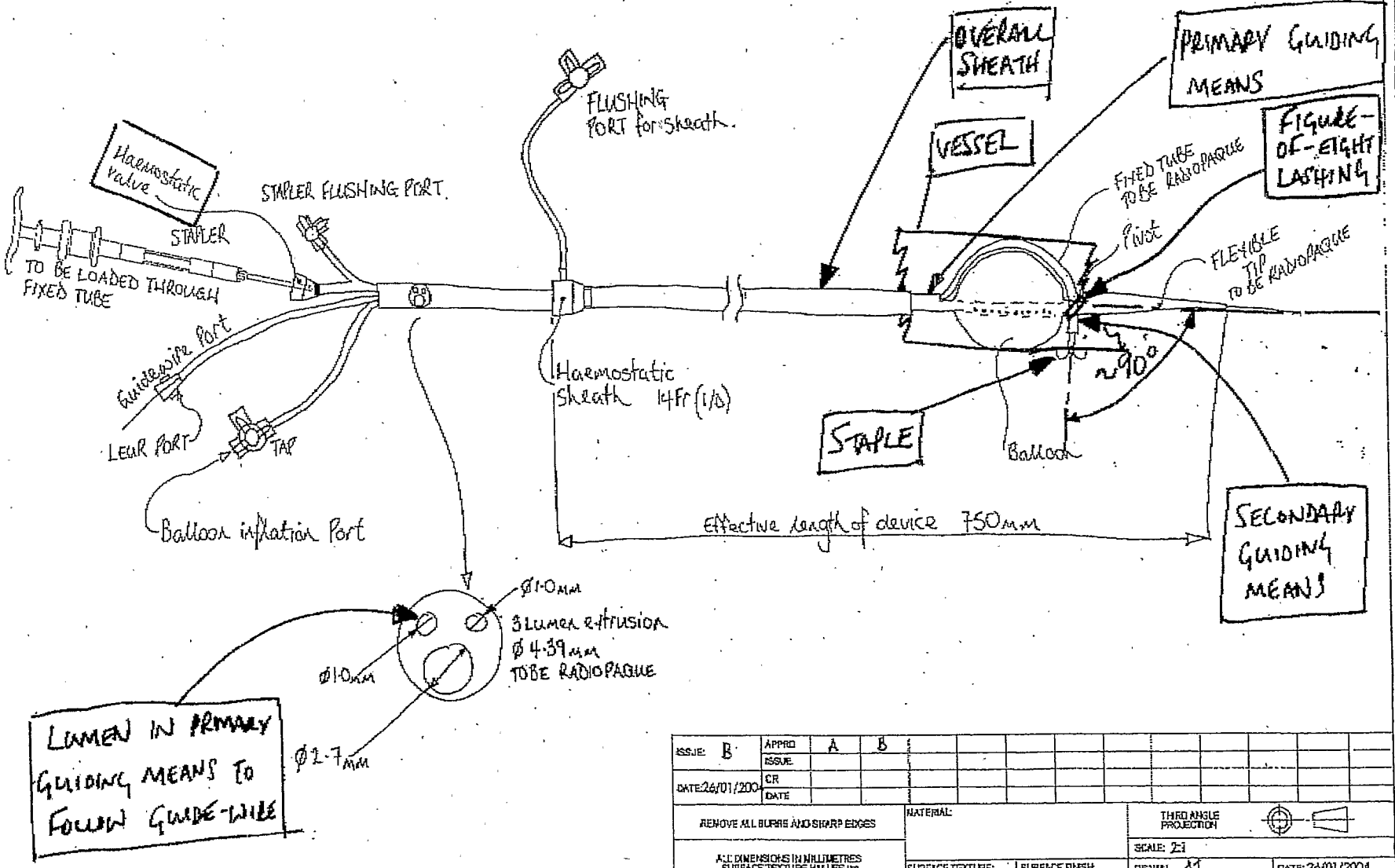
- The delivery catheter is withdrawn, If necessary completely from the delivery system.

- A new delivery catheter containing a new staple is pushed into the delivery system and advanced to the wall of the vessel.

- The pressure in the balloon is dropped slightly and the tip of the delivery catheter is repositioned to the delivery site for the new staple.

- The sequence is repeated.

A delivery system in accordance with the present invention is shown in the accompanying drawings.



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REMOVE ALL BURRS AND SHARP EDGES

ALL DIMENSIONS IN MILLIMETRES
SURFACE TEXTURE VALUES µm
TOLERANCE UNLESS OTHERWISE STATED
WHOLE NUMBERS ± 0.25
ONE DECIMAL PLACE ± 0.10
TWO DECIMAL PLACES ± 0.05
ANGULAR ± 1°

MATERIAL:

THIRD ANGLE PROJECTION

SCALE: 2:1

SURFACE TEXTURE: SURFACE FINISH:

DRAWN: AJ DATE: 26/01/2004

CHECKED: DATE:

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ANSON MEDICAL

TITLE: ENDOREFIX - LAYOUT DRAWING

DRG No: P025-0006-DR